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#### BFGRP0313USB

#### IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:

John W. Robinson et al. :

Group Art Unit: 1712

Serial No: 10/612.850 : Examiner

Examiner: Robert E. Sellers

Filed: July 3, 2003

Confirmation No: 6883

FOI: RUBBER TOUGHENED EPOXY RESINS FOR RESIN INFUSION PROCESSING,
METHODS OF USING THE RESINS AND ARTICLES MADE THEREFROM

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P.O. Box 1450

Alexandria, VA 22313-1450

## APPLICANT'S BRIEF ON APPEAL

#### Dear Sir:

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This Appeal Brief is submitted in the above-identified application in response to the Final Office Action mailed December 20, 2006. Appellant's Notice of Appeal was filed on April 18, 2007. Accordingly, Appellant's Appeal Brief is timely filed, with no extensions of time.

#### I. REAL PARTY IN INTEREST

The real party in interest is Goodrich Corporation, 4 Coliseum Centre, 2730 West Tyvola Road, Charlotte, North Carolina 28217-4578, the assignee of the above-captioned application.

## II. RELATED APPEALS AND INTERFERENCES

Appellants are aware of no related appeals or interferences that will directly affect or be directly affected by or have a bearing on the Board's decision in the instant appeal.

#### III. STATUS OF CLAIMS

Claims 1-3, 8-9, 11, and 30 are pending in the application. Claims 1-3, 8-9, 11, and 30 are finally rejected and are the subject of the present Appeal. The claims on appeal are reproduced in the attached APPENDIX.

#### IV. STATUS OF AMENDMENTS

An amendment under 37 C.F.R. §1.116 was filed on February 20, 2007, in which Appellant cancelled claims 7 and 13-29. In the Advisory Action dated March 1, 2007, the Examiner entered the amendment filed on February 20, 2007.

#### V. SUMMARY OF THE CLAIMED SUBJECT MATTER

In an embodiment of the invention described in independent claim 1, a curable composition comprises (a) at least one epoxy resin (page 1, lines 12-14), (b) at least one liquid reactive polymer comprising a carboxyl-terminated butadiene-acrylonitrile copolymer (page 1, lines 12-14; page page 10, lines 15-17), which polymer is liquid at room temperature (page 7, line 28; pages 8-14; page 17, lines 9-10) and (c) at least one reaction product of an epoxy resin and a reactive liquid polymer (page 1, lines 12-14), wherein the

epoxy resin of (c) comprises a diglycidyl ether of a bisphenol compound (page 14, lines 22-24).

## VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

- A. The rejection of claims 1-3,8, 9, and 11 under 35 U.S.C. 112, first paragraph as not complying with the enablement requirement
- B. The rejection of claims 1-3, 8, 9, and 11 under 35 U.S.C. 103(a) as being unpatentable over U.S. Patent No. 4,500,660 to Minamisawa et al.

#### VII. ARGUMENT

## A. The Rejection under 35 U.S.C. § 112 Should Be Reversed

#### The Examiner's Rejection:

Claims 1-3, 8, 9, and 11 have been rejected under 35 U.S.C. §112, first paragraph, as not complying with the enablement requirement. The Examiner contends that that an epoxy resin must contain at least two epoxy groups and single functional epoxides such as octadecyleneoxide, epichlorohydrin, styrene oxide, vinylcyclohexene oxide, and glycidyl methacrylate (which are identified in the specification) do not conform to the art recognized definition of a resin. (Office Action, January 18, 2006, page 2.) The Examiner states that (i) an epoxy compound cannot form a curable composition unless more than one epoxy group is present to react with more than one reactive group of a curing agent to form a cured network, and (ii) the presence of monoepoxides by themselves cannot form a cured product unless present in an admixture with an epoxy resin containing more than one epoxy group. (Final Office Action, December 20, 2006, page 3.) In the Advisory Action, the Examiner stated that the reaction of a single epoxy group cannot yield a two- or threedimensional network. (Advisory Action, March 1, 2007.) The Examiner also contends that the specification indicates that an epoxy resin requires more than one epoxy group. (See Final Office Action, December 20, 2006, page3 (citing page 5 line 29 to page 6, line 1 of the specification).)

#### Appellants' Response:

Claim 1 recites a curable composition comprising (a) at least one epoxy resin, (b) at least one reactive liquid polymer comprising carboxyl-terminated butadiene-acrylonitrile copolymer, which polymer is liquid at ambient temperature, and (c) at least one reaction product of an epoxy resin and a reactive liquid polymer, wherein the epoxy resin of (c) comprises a diglycidyl ether of a bisphenol compound.

The test for enablement is whether the disclosure, when filed, enables a person skilled in the art to make and use the claimed invention without undue experimentation. (MPEP § 2164.01.) The enablement requirement is satisfied where the specification discloses at least one method for making and using the claimed invention that bears a reasonable correlation to the scope of the claim. (MPEP § 2164.01(b).) The Examiner bears the initial burden to establish a reasonable basis to question the enablement provided for the claimed invention. (MPEP § 2164.04.) The Examiner's conclusion of enablement should focus on why the specification fails to teach (i) how to make and use the claimed invention (ii) without undue experimentation. (Id.) The Examiner must explain why it doubts the truth or accuracy of a disclosure and back up its assertions with acceptable evidence that is contrary to the contested statement. (MPEP § 2164.04.)

Enablement is evaluated against the claimed subject matter, and the Examiner must consider the claim as a whole rather than analyzing its parts individually. (MPEP § 2164.08.) A rejection based on the scope of the claim relative to the scope of enablement requires evaluating whether a person skilled in the art could make or use the entire scope of the claimed invention without undue experimentation. (Id.) When evaluating the enabled scope, the teachings in the specification must not be ignored because claims are to be given their broadest reasonable interpretation that is consistent with the specification. (Id.)

The rejection of claims 1-3, 8, 9, and 11 as not complying with the enablement requirement is based solely on the Examiner's interpretation or construction of the term "epoxy resin." The Examiner contends that the term "epoxy resin" should not encompass epoxides with only one epoxy group. Specifically, the Examiner contends that a component with a single epoxy group (i) does not conform to the art recognized definition, and (ii) is not capable of being converted to a thermoset.

Appellants respectfully submit that the Examiner has not met the burden to establish lack of enablement. The Examiner has not provided a reasonable basis in fact that the claims are not enabled. In the various rejections, the Examiner contends that the art recognized definition for an "epoxy resin" is an epoxide with two or more epoxy groups. The Examiner only relies on <a href="The Handbook of Epoxy Resins">The Handbook of Epoxy Resins</a> to support this position. (See April 21, 2006 Office Action, page 3.)

The Examiner's evidence, however, does not demonstrate an art recognized definition for the term "epoxy resin." The definition of epoxy resin to which the Examiner refers in The Handbook of Epoxy Resins specifically states that "For the purpose of this book, an epoxy resin is defined as any molecule containing more than one α-epoxy group..." (emphasis added).¹ The qualifying statement "for the purpose of the book" indicates that it is not a generally accepted convention in the art that an epoxy resin would require at least two epoxy groups.

Appellants have also provided evidence that is sufficient to overcome the Examiner's assertion that epoxy resins require at least two epoxy groups. For example, The <u>Concise Encyclopedia of Chemical Technology</u>, Kirk-Othmer, 4<sup>th</sup> Ed. 1999, describes an epoxy resin as being "characterized by the presence of <u>a</u> three-dimensional ring known as the epoxy, epoxide, oxirane, or ethoxyline group" (emphasis added).<sup>2</sup> That is, an epoxy resin may be characterized by the presence of a single epoxy group. There is no stated requirement for more than one epoxy group.

Additionally, <u>Hawley's Condensed Chemical Dictionary</u>, Twelfth Edition, 1993, does not define an epoxy resin as requiring at least two epoxy groups. <u>Hawley's</u> states that an "epoxy resin" is a resin that is "based on the reactivity of the epoxide group." Using the singular term "epoxide group" indicates that two or more epoxy groups are not required for an epoxy resin. Nothing in the definitions for "epoxide" or "epoxy resin" requires at least two epoxy groups.

The Examiner attempted to use the <u>Hawley's</u> definition to rebut Appellants' arguments. In particular, the Examiner stated that "[t]he term epoxy resin is defined in the submitted Hawley's Condensed Chemical <u>Dictionary</u> (page 468, second column) as having

<sup>1</sup> See Exhibit A

<sup>&</sup>lt;sup>2</sup> Exhibit B

<sup>3</sup> Exhibit C

'glycidyl ether structures' and the epoxide group structure 'in the terminal positions,' thereby confirming the presence of at least two epoxy groups per molecule." (Advisory Action, July 10, 2006, page 2.) The Examiner's argument, however, does not undermine Appellant's evidence. When the statements relied on by the Examiner are viewed in full context, they do not support the proposition that all epoxy resins require at least two epoxy groups. Specifically, <u>Hawley's</u> states that:

One type [of epoxy resin] is made from epichlorohydrin and bisphenol A. Aliphatic polyols such as glycerol may be used instead of the aromatic bisphenol A. Molecules of this type have glycldyl either structures... in the terminal positions, have many hydroxyl groups, and cure readily with amines.

(Emphasis added, structure omitted.)

That is, the <u>Hawley's</u> definition merely indicates that an example of an epoxy resin is one made from epichlorohydrin and bisphenol A (or aliphatic polyols), and that "molecules of this type," i.e., molecules of epichlorohydrin and bisphenol A (or aliphatic polyols), have terminal glycidyl ethers. This statement does not indicate that all epoxy resins must have at least two epoxy groups.

Thus, the evidence does not demonstrate an art recognized definition for epoxy resin that requires two epoxy groups. As described above, the evidence actually demonstrates that an epoxy resin may include a single epoxy group.

Further, the specification does not limit an epoxy resin to a compound containing two or more epoxy groups. The Examiner contends that the specification states that an epoxy resin is a compound containing more than one epoxy group capable of being converted to a useful thermoset or cured state by a curing agent. (See December 20, 2006 Final Office Action, page 3 (citing page 5, line 29 to page 6, line 1).) This passage, however, does not limit an epoxy resin to a compound containing more than one epoxy group. When the specification is considered as a whole, the specification indicates that an epoxy resin may include structures or compounds with only one epoxy group. Specifically, the specification states that a wide variety of commercially available epoxy resins can be used in the invention and then includes octadecylene oxide, epichlorohydrin, styrene oxides, vinylcyclohexene oxides and glycidyl methacrylate in a list of suitable examples. (Specification, page 6, lines 29-30 through page 7, lines 1-25.) The Examiner can not ignore this teaching. (MPEP § 2164.08.) Therefore, when the specification is considered

as a whole and the claims given their broadest reasonable interpretation that is consistent with the specification, the specification sets out with reasonable clarity that an epoxy resin may include structures with one epoxy group.

The Examiner has also failed to show that undue experimentation would be required to practice the invention. An enablement rejection should focus on why the specification fails to teach how to make and use the claimed invention without undue experimentation. (MPEP § 2164.04.) The Examiner argues that a monoepoxide could not form a network. But the Examiner fails to provide any support for this position.

The specification teaches how to make and use the claimed invention and, therefore, fully enables the claimed invention. The specification describes how to make the curable composition. For example, the specification states that the components of the curable composition may be blended at ambient or slightly elevated temperatures. (Specification, page 17, lines 8-10.) Further, the specification teaches how to use the curable compositions, e.g., how to cure them. (See, e.g., specification, pages 15-17; page 15, lines 11-20; page 17, lines 8-20.) Thus, the specification discloses at least one method of making and using the claimed invention. Further, the disclosed method(s) bears a reasonable correlation to the scope of the claims in that nothing limits the method(s) to using any particular epoxy resin. Consequently, the enablement requirement is satisfied. (See MPEP § 2164.01(b).)

Moreover, the claims are directed to a curable composition. A person skilled in the art would recognize that curing includes changing the physical properties of a material by a chemical reaction and/or heat. A single epoxy group is capable of reacting with a curing agent, and therefore capable of being cured (or converted to a cured state). For example, a person skilled in the art would recognize that a compound having a single reactive group, such as a monoepoxide, can form lineal and cross-linked networks if reacted in the presence of another chemical that has two or more sites with moieties that can react with the reactive group. The specification states that the curable composition may be cured using any known curing agent and that curing agents known to those skilled in the art include amines, acids, alcohols, and the like. (Page 15, lines 11-13.) Appellants submit that a person skilled in the art would recognize that a network could be formed by reacting a mono-epoxy with a difunctional or multifunctional curing agent, such as, for example, a diamine or multifunctional amine.

Further, when the claim is viewed as a whole, the Examiner's arguments fail. The Examiner argues that "monoepoxides by themselves cannot form a cured product unless present in an admixture with an epoxy resin containing more than one epoxy group." (Final Office Action, December 20, 2006, page 3.) Claim 1 requires a component (c) that is the reaction product of an epoxy resin and a reactive liquid polymer where the epoxy resin of (c) comprises a diglycidyl ether or a bisphenol compound. A diglycidyl ether of a bisphenol includes at least two epoxy groups. Therefore, the curable composition includes an epoxy component with two or more epoxy groups. Thus, the specification teaches how to make and use the invention that bears a reasonable relationship to the scope of the invention. There is nothing to suggest that undue experimentation would be required to practice the claimed invention.

Thus, the evidence, including the specification itself, demonstrates that an epoxy resin as used in the claims does not require more than one epoxy group. Moreover, there is nothing to suggest that undue experimentation would be required to practice the invention. Rather, in view of the specification, a person skilled in the art would have (i) known the scope of the claims, and been apprised that an epoxy resin can include readily available compounds including monoepoxides, and (ii) been able to make or use the full scope of the invention without undue experimentation. Thus, in view of the above discussion, Appellants respectfully request that the rejection of claims 1-3, 8-9, and 11 under 35 U.S.C. §112, first paragraph, be reversed.

#### The Rejection Under 35 U.S.C. § 103 Should Be Reversed

#### The Examiner's Rejection:

The Examiner rejected claims 1-3, 8, 9, and 11 under 35 U.S.C. § 103(a) as being unpatentable over Minamisawa et al. (U.S. Patent No. 4,500,660) and Japanese Patent No. 64- or 01-060679. The Examiner contends that it would have been obvious to formulate the compositions of Minamisawa and JP '679 "with the carboxy-terminated butadiene-acrylonitrile as a liquid at room temperature in order to facilitate blending of the components." (Office Action, September 1, 2006, page 4.) The Examiner also contends that Minamisawa discloses reacting a carboxy-terminated butadiene-acrylonitrile in liquid form with an epoxy resin to facilitate the reaction with the epoxy and provide a prepreg of good quality and that it would be obvious to provide the carboxy-terminated butadiene-

acrylonitrile of Minamisawa and the Japanese references in liquid form. (Advisory Action, March 1, 2007, page 2.)

#### Appellants' Response:

At the least, in order to establish a prima facie case of obviousness, the prior art references must teach or suggest all the claim limitations. (MPEP §§ 2143, 2143.03.) Further, the Examiner must make particular findings as to a person skilled in the art would modify the prior art in the manner claimed. (See, In re Kotzab, 217 F.3d 1365, 1371 (Fed. Cir. 2000) (cited in MPEP § 2143.01 (I)).)

Minamisawa and JP '679 fail to teach all the claim limitations. Minamisawa is directed to a composition that includes epoxy resins (A-C), a reaction product of a carboxy-terminated butadiene-acrylonitrile copolymer (D), and a nitrile rubber (E). The Examiner has continuously equated the nitrile rubber component (E) of Minamisawa to component (b) of Appellants claim. (See, e.g., Office Action, April 21, 2006, page 3.)

Neither Minamisawa nor JP '679 teach a curable composition employing at least one reactive liquid polymer comprising a carboxyl-terminated butadiene-acrylonitrile copolymer, which polymer is liquid at ambient temperature. The nitrile rubber component of Minamisawa and the Japanese references (Nipol in each case) are solids.<sup>4</sup> Further, Minamisawa only discloses that suitable nitrile rubbers have a Mooney viscosity between 40 and 110 at 100°C. Thus, these references fail to teach or suggest using a reactive liquid polymer comprising a carboxyl-terminated butadiene-acrylonitrile copolymer that is liquid at ambient temperature, and, therefore, fail to render the claims obvious.

The Examiner contends that Minamisawa and JP '679 do not confine their polymers to any phase. In particular, the Examiner contends that Minamisawa discloses that a nitrile rubber such as a carboxyl-modified copolymer of butadiene and acrylonitrile with a Mooney viscosity of 40 and 110 at 100°C is suitable but not exclusive and the JP '679 report carboxy-terminated copolymers without any phase.

Appellants respectfully submit that when the reference are considered as a whole, there is nothing in the references to suggest utilizing at least one reactive liquid polymer that is ambient at room temperature. First, the Mooney viscosities disclosed in

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<sup>4</sup> See Exhibit D

Minamisawa are measured at 100°C, which is well above ambient temperature. Second, as described above, the references only disclose Nipol polymers, which are solids. Thus, even if the references do not explicitly confine their copolymers to a particular phase, they do not teach or suggest that the polymer should be a liquid at ambient temperature. To the contrary, Minamisawa and JP '679 teach that their compositions would have to be formed by blending the solid components at an elevated temperature. The fact that a reference could be modified does not render a claim obvious unless. (MPEP § 2143.01(III).)

Further, while Minamisawa may disclose that the carboxy-germinated butadieneacrylonitrile may be a liquid in forming the reaction product component (D), the references
do not disclose a composition that includes a separate reactive liquid polymer component
(distinct from a component that is the reaction product of an epoxy and a CTBN). Again,
the Examiner contends that Minamisawa's component (E) equates to component (b) in
Appellants claims. The references cited by the Examiner, however, only disclose a solid
component (Nipol rubbers) as the (E) component for Minamisawa's composition. Given
that Minamisawa discloses using a liquid CTBN to form the reaction product component
(D) for its composition and only discloses using solid nitrile rubbers as its component (E),
Appellants submit that Minamisawa actually teaches away from using a separate reactive
liquid polymer component. Rather, it is only through prohibited hindsight that a person
skilled in the art would modify Minamisawa to arrive at the present claims.

Further, Minamisawa's disclosure of dissolving the composition in a solvent does not render the claims obvious. Minamisawa discloses that an already formed epoxy composition may be used as a prepreg, which is produced by dissolving the already formed composition in a solvent and impregnating reinforcing fibers with that solution. ('660 patent, col. 6, lines 44-65.) The fact that the already formed resin may be dissolved does not teach or suggest that the resin composition comprises a reactive liquid polymer (comprising a carboxyl-terminated butadiene acrylonitrile copolymer) that is liquid at ambient temperature. Again, it is only through prohibited hindsight in view of Applicants' disclosure that a person skilled in the art would arrive at the present claims.

Regarding claims 8 and 30, neither reference cited by the Examiner remotely teaches employing a reactive liquid polymer having a Brookfield viscosity of from about 500 to about 2.500.000 cps at 25°C. The Examiner contends that it would have been

obvious to employ the polymers disclosed in liquid form with such viscosities to facilitate blending. Appellants disagree with this contention. First, the references completely fail to teach or suggest using a copolymer having a Brookfield viscosity with the recited range. Second, as described above, at the most, the references only teach using polymers that are solid or have a particular Mooney viscosity at 100°C. Thus, there is no teaching or suggestion to employ a liquid polymer having a Brookfield viscosity as recited in claims 8 and 30. The fact that a person skilled in the art could modify a reference is not sufficient to establish a prima facie case of obviousness. (MPEP § 2143.01(III).) Therefore, claims 8 and 30 are not obvious in view of either Minamisawa or JP '697.

In view of the above discussion, Appellants submit that the combination of Minamisawa and JP '679 do not render the claims obvious. Appellants respectively request that the rejection under § 103(a) be reversed.

#### VIII. CONCLUSION

For the foregoing reasons, the honorable Board is requested to reverse the Examiner's rejection of all of the claims pending in the application and to allow these claims.

In the event any fees are due in connection with the filing of this document, the Commissioner is authorized to charge those fees to our Deposit Account No. 18-0988 under Attorney Docket No. <u>BFGRP0313USB</u>. In the event an extension of time is needed to make the filing of this paper timely and no separate petition is attached, please consider this a petition for the requisite extension and charge the fee to our Deposit Account No. 18-0988.

In the event there are issues the Examiner would like to discuss with the Applicants' attorney, he is invited to contact the undersigned by phone.

Respectfully submitted,

RENNER, OTTO, BOISSELLE & SKLAR, LLP

Neil A. DuChez

Reg. No. 26,725

1621 Euclid Avenue, 19<sup>th</sup> Floor Cleveland, Ohio 44115-2191 (216) 621-1113

Attachments: Exhibit A, Exhibit B, Exhibit C, and Exhibit D

#### APPENDIX

#### CLAIMS SUBJECT TO APPEAL

- 1. A curable composition comprising a) at least one epoxy resin, b) at least one reactive liquid polymer comprising a carboxyl-terminated butadiene-acrylonitrile copolymer, which polymer is liquid at ambient temperature, and c) at least one reaction product of an epoxy resin and a reactive liquid polymer, wherein the epoxy resin of (c) comprises a diglycidyl ether of a bisphenol compound.
- 2. The composition of claim 1 wherein a) is a diglycidyl ether of a bisphenol compound.
  - 3. The composition of claim 1 wherein a) is a diglycidyl ether of bisphenol F.
- 8. The composition of claim 1 wherein b) has a Brookfield viscosities of from about 500 cps to about 2,500,000 cps at  $25^{\circ}$  C.
- 9. The composition of claim 1 wherein c) is a reaction product of 1) a dicarboxyl-terminated polymer, a dihydroxy-terminated polymer, a diepoxy-terminated polymer, a reaction product statistical monofunctional carboxyl-terminated polymer, a reaction product statistical monofunctional hydroxy-terminated polymer, a reaction product statistical monofunctional epoxy-terminated polymer, a blended product statistical monofunctional carboxyl-terminated polymer, a blended product statistical monofunctional hydroxy-terminated polymer, a blended product statistical monofunctional epoxy-terminated polymer or mixtures of two or more thereof and 2) at least one epoxy resin comprising a diglycidyl ether of a bisphenol compound.
- 11. The composition of claim 1 wherein c) is a reaction product of 1) at least one epoxy resin comprising a diglycidyl ether of a bisphenol compound and 2) a dicarboxyl-terminated polymer, a reaction product statistical monofunctional carboxyl-terminated

polymer, a blended product statistical monofunctional carboxyl-terminated polymer, or mixtures of two or more thereof.

30. A curable composition comprising a) at least one epoxy resin, b) at least one reactive liquid polymer comprising a carboxyl-terminated butadiene-acrylonitrile copolymer, and c) at least one reaction product of an epoxy resin and a reactive liquid polymer, wherein the reactive liquid polymer of (b) has a Brookfield viscosity of from about 500 cps to about 2,500,000 cps at 25°C and the epoxy resin of (c) comprises a diglycidyl ether of a bisphenol compound.

#### **APPENDIX**

## **EVIDENCE**

Supporting Evidence is included in attached Exhibits A-D.

#### **APPENDIX**

## RELATED PROCEEDINGS

None

#### OOKS OF INTEREST

or Mechanical Engineers

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ook of Industrial Loss Prevention ectrical Engineers

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andbook Scientists and Engineers

landbook

ineers Handbook

al Properties Research Literature

Exhibit A 1/3

# HANDBOOK OF **EPOXY RESINS**

#### HENRY LEE

Technical Director, The Epoxylite Corporation South El Monte, California

#### KRIS NEVILLE

Project Engineer, The Epoxylite Corporation South El Monte, California

Prb. 1967

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## Chapter 1

#### AN INTRODUCTION TO EPOXY RESINS

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In a broad sense, the term epoxy refers to a chemical group consisting of an oxygen atom bonded with two carbon atoms already united in some other way. The simplest epoxy is a three-membered ring, to which the term e-epoxy or 1,2-epoxy is applied. Ethylene oxide (1) is an example of this type. The terms 1,3 and 1,4-epoxy are applied to trimethylene oxide (1) and tetrahydrofuran (11).

In this book, we are concerned only with resins containing the three-membered rings (e.g., ethylene oxide derivatives).

There is no universal agreement on the nomenclature of the three-membered epoxy ring. There is division even on the term epoxy itself—the Europeans generally preferring the term epoxiek, which is doubtless more correct than the American epoxy. The epoxies may be designated oxides, as in the case of ethylene oxide (epoxyethane) or cyclofickene oxide (1,2-epoxy, or 1,2-oxidocyclohexane) (IV). The term oximum, a trivial name for ethylene oxide, is also used in referring to the epoxy group. Several of the more common monoepoxies have trivial names,

#### -2 An Introduction to Epoxy Resins

such as epichlorohydrin (V), glycidic acid (VI), and glycidol (VII). Glycidyl (VIII)

is used to refer to the terminal epoxy group, the name being modified by ether, ester, amine, etc., according to the nature of the group attached to the third carbon.

amme, etc., according to the manue of a good in the United States. Trivial We prefer to follow the usage generally accepted in the United States. Trivial names are identified by structural formula to avoid confusion. The useful term glycidy) is used throughout the text, with epoxy and oxide following the current usage in the United States technology.

#### DEFINITION OF EPOXY RESIN

For the purpose of this book, an <u>epoxy resibis</u> defined as any molecule containing more than one <u>α</u>-epoxy group (whether situated internally, terminally, or on cyclic structures) capable of being converted to a useful thermoset form. The term is used to indicate the resins in both the thermoplastic (uncured) and thermoset (cured) state.

#### HISTORY

Epoxy resins are prepared commercially (1) by dehydrohalogenation of the chlorohydrin prepared by the reaction of epichlorohydrin with a suitable di- or polyhydroxyl material or other active-hydrogen-containing molecule; (2) by the reaction of oldens with oxygen-containing compounds such as peroxides or per-eaction of oldens with oxygen-containing compounds such as peroxides or per-acids, and (3) by dehydrohalogenation of chlorohydrins prepared by routes other

than route 1.

Schrade [21] cites the first commercial attempt to prepare resins from epichlorohydrin as occurring in 1927 in the United States. However, credit for the synthesis
of the materials first designated as epoxy resins—those derived specifically from
epichlorohydrin and bisphenol A—is shared by Dr. Pierre Castan of Switzerland
and Dr. S. O. Greenlee of the United States. There enes are still by far the most
important in the technology.

In 1936 Dr. Castan produced a low-melting, amber-colored resin which was then reacted with phthalic anhydride to produce a thermoset compound. Dr. Castan, working for De Trey Frères of Switzerland, envisioned the use of such liquid resins in the manufacture of dentures and cast articles [13,14,16,17,21]. His developments were subsequently licensed to Closa, Ltd.

were subsequently licensed to Ciba, Ltd.

In the United States, Dr. Greenlee, early in 1939, working for Devoe-Raynolds, explored the epichlorohydrin-bisphenol A synthesis route for the production of new explored the epichlorohydrin-bisphenol a synthesis route for the production of new results for coatings, these resins not containing caustic-sensitive ester linkages [18,20].

The epichlorohydrin-bisphenol resins were the outgrowth of several decades of research by many workers on the broad front of substituted ethylene oxide derivatives. Without detracting from the credit due Drs. Castan and Greenlee, reference should be made to earlier discoveries which set the stage for the epoxy resins and

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# CONCISE ENCYCLOPEDIA OF CHEMICAL TECHNOLOGY

4th EDITION



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John Wiley & Sons, Inc.

#### EPOXY RESINS 758

usually treated with an iv-administered pressor amine, including isoproterenal (beta agonist selective) NE, E, DA, and dobutamine. E is also the primary treatment for anuphylactic shock. E is commonly included in local assethetic solutions to promote hemostasis, and by vasoconstriction to reduce absorption resulting in prolongation of anesthesia. Several related sympathomimatic vasoconstrictor amines (eg, phenylephrine hydrochloride) are used for usual congretion. Because of their relaxation of bronchial amouth muscle, E and selected beta-2 agonists are used to antagonize the brouchospasm observed in asthma. NE is used for treating hypotension during anesthesia when tissue perfusion is good.

ha-adrenergic blocking agents such as prazosin (alpha-1 selec-Alp tive), which causes vasodilation in both arteries and vains without usually causing reflex tachycardia, are used to treat mild to moderate hypertension. Nonselective beta-advenergic entagonists such as propranolol are used in the treatment of hypertension (usually with a diuretic), as prophylaxis in angine pectoris, and for prophylaxis of supraventricular and vantricular arrhythmias and other selected disorders. Selective bets-1 adrenergic antagonists such as metoprolol are used mainly for the treatment of hypertension. In addition, clonidine (an alpha-2 agonist) and methyldopa (metabolized to alphamethylporepinephrine in brain) act centrally on vasomotor centers of the brain to reduce sympathetic outflow to the peripheral vessels and thus are used, but to a losser extent, in the treatment of hypertensic

In Parkinson's disease, treatment with the amine precursor DOPA (with the decarboxylase inhibitor carbidops), has been shown to ame ligrate the symptoms and signs of the condition and prolong life. There are several other disorders of the central nervous system

in which catecholomines have been shown to be involved and druging that affect the actions of catecholamines have a therapeutic act Dopamine receptor antagonists that encompass several chemical classes such as phenothiszines (eg. chlorpromazine, butyrophenones (eg. haloperidol, and thioxanthene derivatives (eg. chlorprothixene, are prescribed for the management of both scute and chronic psy choses and in namesychotic individuals who are delurional or conited (eg, manis). In the treatment of depression, most antidepressants are believed to improve mood by increasing catecholamine and/or serotonin concentrations.

orides behavior and blood pressure, catecholomine neurons als have important rules in other brain functions. Regulation of neuroen-docrine function is a well-known action of catecholarnines; for example, DA agonists reduce serum prolectin concentration, especially in conditions of hypersecretion. Ingestive behavior can be modulated by brain catecholamines, and some appetite-suppressing drugs are believed to act via catecholaminorgic influences. Catecholamines also participato in regulation of body temperature.

Untoward effects of both E and NE (usually to a lesser degree) are anxiety, headache, cerebral hemorrhage (from vasopressor effects), cardiac arrhythmias, especially in presence of digitalis and certain anesthetic agents, and pulmonary edema as a result of pulmonary hypertension. The minimum subcutaneous lethal dose of E is about 4 mg, but recoveries have occurred after accidental overdosage with 16 mg subcutaneously and 30 mg intravenously, followed by immediate supportive treatment.

> THOMAS A. PUCSLEY Warner-Lambert/Parke-Davis

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#### FPOXY RESINS

Epoxy resins are characterized by the presence of a three-state ring known as the epoxy, epoxide, oxirsue, or ethoxyline gre ne contain aliphatic, cycloaliphatic, or are cial spoty res backbones. The capability of the epoxy ring to react with a varisubstrates imparts versatility to the resins. Treatment with agents gives insoluble and intractable thermoset polymers. In to facilitate processing and modify cured resin properties will constituents may be included in the compositions: fillers, set diluents, plasticizers, accelerators, curatives, and tougheners

#### Resin Properties

Epichlorohydrin and Bisphenol A-Derived Resurs. The most wish and epoxy rasins are digiyatdyl ethers of hisphenol A (1) derived his hisphenol A and epichlorohydria.

The outstanding performance characteristics of the resins are to veyed by the hisphenol A moiety (toughness, rigidity, and sires temperature performance), the other linkages (chemical resistant and the hydroxyl and epoxy groups (adhesive properties and fi-lation latitude, or reactivity with a wide variety of chamical in agents) (see also PHENOLIC RESINS).

The bisphenol A-derived epoxy resins are most frequently ex

with subydrides, aliphatic amines, or polyamides.

Diluents are commonly used to reduce the viscosity of s systems to administry use of application, and to feeling systems to side handling, improve case of application, and to feelin higher filler loading to reduce formulation cost. This, however achieved at the expense of other properties. To achieve a beliare properties, careful selection of dilport is needed.

Specialty Epoxy Resins. In addition to hisphenol, other such as aliphatic glycols and novolaks are used to produce a resins. Epoxy resins may also include compounds based on all cyclooliphatic, aromatic, and heterocyclic backbones. Glyddi of active hydrogen-containing structures with epichlorchydrin opoxidation of olefine with personic acid remain the important on mercial procedures for introducing the oxirane group into ve 200 precursors of spoxy resins.

Epoxy Cresol-Novolak Resins (ECN). The cresol-novolak resins (2) are multifunctional, solid polymers characterized by ionic and hydrolyzable chlorine impurities, high chemical resi and good thermal performance. ECN rosins are widely used as components in high performance electronic and structural sperature adhesives, castings and leads compounds, high ter systems, tooling applications, and powder contings.

The epoxy cresol-novelok regins (2) are prepared by girthy of o-cresol-formaldehyde condensates in the same manner as nol-novelak resin

Bisphenol F Resin. Bisphenol F spony resin is of the same structure as the epoxy phenol novelske. Bisphenol F is 2,2

Owing to relatively low viscosity, these resins offer silvi 100% salids (solvent-free) systems. Higher filler levels are because of the low viscosity. Faster bubble release is also Higher epary content and functionality of hisphenel F court

EPOXY RESINS

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an'pairide improved chemical resistance compared to conventional

processing of the sporty resins are used in high-solids high-build systhe such as tank and pipe linings, industrial floors, road and bridge tem such as tank and pipe linings, industrial floors, road and bridge dark toppings, atructural adhesives, grouts, contings, and electrical den toppings, and ciectrical straints are manufactured in Europe and

en. . fjory Phenol-Novolak Resina Epoxy phenol-novolak resins are magnited by the general idealized structure (3) whereby multifuncrepresented by the products are formed containing a phenolic hydroxyl group per phenyl ring in random para-para', ortho-para', and ortho-ortho' combinations.

Subsequent epoxidation with epichlorohydrin yields the highly togetional spoxy novolak. The product can range from a high viscosity Hould of n = 0.2 to a solid of n value greater than 3.

The thermal stability of epoxy phenol-novolak regins is useful in adhesives, structural and electrical luminates, coatings, castings, and encapsulations for elevated temperature service. Filament-wound pips and storage tanks, liners for pumps and other chemical process equipment, and corrosion-resistant contings are typical applications using the chemically resistant properties of epoxy novolak resins.

Curing agents that give the optimum in elevated temperature properties for epoxy novelake are those with good high temperature performance such as aromatic amines, catalytic curing agents,

phenolics, and some supporties.

Polynoless Phenol-Glycidyl Ether-Derived Resins. This is one of the

first commercially available polyfunctional products. Its polyfunction ally permits upgrading of thermal stability, chemical resistance, and electrical and mechanical properties of hisphenol A—epoxy systems. It is used in molding compounds and adhesives.

Cyclosliphatic Spary Resins. This family of aliphatic, low viscosity spary resins consists of two principal varieties, cycloolefins epoxidized with paramete soid and distraidyl enters of cyclic dicarboxylic acids.

The nonaromatic nature of these materials provides for improved tweedstance and arc-track resistance compared to conventional sporiss. The best properties are generally schieved with anhydride and phenolic curing agents.

Recommended applications include transformers, insulators, bush ings, wire and cable coatings, generators, motors and switchgear, additives for adhesives, vinyl stabilization, and as viscosity depressents.

Aromatic and Heterocyclic Glycidyl Amine Resins. Among the spe-dalty openy resins containing an aromatic amine backbone, the follow-

ing are commercially significant.

Ietzelyckly/methylenedianiline-Derived Resins. Resins from areand experimental processes and the second se

Individual p-Aminophenol-Derived Resins. Besins derived from being realized p-aminophenol, originally developed by Union Carbide Comp., are currently marketed by CIBA-GEIGY. Synthesis is conout, are currently marketed by CHSA-tield I. Symmons is our detted by reaction of spichkerohydrin with the phenolic and amino groups followed by dehydrohalogenation. The product is a viscous legid (1.8—6 Pa.s (15—50 P) at 25 °C) which is considerably more re-ation.

office (L5-6 Per (15-6 P) at 25'U) when is because only more of a directive thereof amines than standard bisphonal A-derived resion.

Used-to increase hast resistance and once speed of bisphonel A
Systems is, these utility is such diverse applications as adhesives,
being compounds, and laminating systems.

Triazine Based Resin. Triglycidyl isocyamurate is a solid resin that provides superior thermal, electrical, and mechanical properties and a recommended for laminates, insulating varnishes, coatings, and adhegives. Widely used as a curing agent for special polyester-based weatherable powder costings, it is also used in electronic applications owing to its rotentism of optical transparancy after aging at temperares up to 150°C and minimal smoke evolution on thermal decompogition (see EMPRODUNG).

The triaxine ring-containing product 1,3,5-triglycidyl isocyamurate is synthesized by stycidylation of synantic acid with epichkenhydrin.

#### Resin Synthesis and Manufacture

Epichlorohydrin and Bisphenol A-Derived Resins. Liquid epoxy representation and appreciate Accessed a confidence of the poly-region may be synthesized by a two-step reaction of an excess of epichlorchydrin to hisphanol A in the presence of an alkaline entalyst. The reaction consists initially in the for mastion of the dichlorchydrin of hisphenol A and further reaction by dahydrohalogenation of the intermediate product with a stoichiometric quantity of alkali.

In recent years, production of liquid reains of higher purity, is, higher monomer content and fewer side-reactions, has been accomplished. This is in response to more stringent product quality

Aliphatic Glycidyl Ethers. Aliphatic epoxy resins have been synthesized by glycidylation of diffractional or polyfunctional polyals such as a 1.4-butanediol, 2.2-dimethyl-1,3-propanedial (neopentyl glycol), polypropylene glycols, glycorol, trimethylolpropane. and pentaerythritol. The epoxidation is generally conducted in two steps: (1) the polyul

is added to spichlorohydrin in the presence of a Lewis acid catalyst (stannic chlorids, borns triflucrids) to produce the chlorohydrin inter-mediate, and (2) the intermediate is dehydrohalogenated with sodium hydroxide to yield the aliphatic glycidyl ether. Solid spoxy resins are

ared by the Taffy or Advancement processes. Taffy Process. Bisphenol A reacts directly with epichlorohydrin in the presence of a stoichiometric amount of caustic. The molecular weight of the product is governed by the ratio of spichlorohydrinbisphenel A. In practice, the taffy process is generally amployed for only medium molecular-weight resins (n=1-4).

Advancement Process. In the advancement proferred to as the fusion method, liquid epoxy resin (crude diglycidy) other of hisphenol A) is chain-extended with hisphenol A in the presence of a catalyst to yield higher polymerized products. The advancement process is more widely used in commercial practice.

In recent years, proprietary catalysts for advancement have been incorporated in precatalyzed liquid resins. Thus only the addition of incorporated in precisely results means and use summer by bispherial A is needed to produce solid epoxy resins. Use of the sata-lysts is claimed to provide resins free from branching which can occur in conventional fusion processes. Additionally, use of the catalysts re-sults in rapid chain-extension reactions because of the high amount of

heat generated in the processing.

The preparation of flame-retardant epoxy resins is accompanied by inclusion of tetrahrumohisphenol A in the advancement process (see FLAME RETARDANTS). Products containing on 20 wt % Br are extensively

employed in the printed circuit board industry.

Liquid resins containing bromine (ca 49 wt %) can also be prepared directly from tetrabromoblephenol A and epichlorohydrin and are used for critical applications where a high degree of flams retardancy is required.

#### **Curing Reactions**

A variety of reagents has been described for converting the liquid and solid spony resins to the cured state, which is necessary for the devel-opment of the inherent properties of the resins. Liquid epoxy resins contain mainly spory groups and solid resins are composed of both spory and hydroxyl curing sites. The curing agents or hardeners are categorized as either catelytic or coreactive and the functional groups 06/21/06 09:33 FAX 216 621 6165

RENNER OTTO

→ USPTO GENERAL

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Hawley's

Condensed Chemical

Dictionary

TWELFTH EDITION

Revised by

Richard J. Lewis, Sr.

VNB

VAN NOSTRAND REINHOLD COMPANY

ew York

RENNER OTTO

RESIST

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resite. See C-stage resin. regital. See B-stage resin.

"Resmetal" [Borden]. TM for a resin-metal Resinetas [portent]. In 101 a 101 a composition that when catalyzed converts to metal-like solid. Recommended for mold making, patching, forming, and general repair of metal surfaces and objects.

resol. See A-stage resin.

resolution. See resolving power.

resolving power. The extent to which a lens can distinguish small particles and minute distances, i.e., fine structure. The human eye can resolve objects of 1/250th inch (100 microns) in any dimension. The compound microscope has a re-solving power of 0.5 micron; an electron microscope can resolve fine structure as small as 5Å units, i.e., in the molecular range. Two factors determine resolving power; the wavelength of the radiation utilized and the focal depth of the lens. The resolving power: of a microscope is much more important than its ability to magnily, for no magnification, however large, can add detail to an image that was not first discerned by the lens system.

See also optical microscope; electron microscope.

resonance. (1) In chemistry, resonance (or me-somerism) is a mathematical concept based on quantum mechanical considerations (i.e., the wave functions of electrons); it is used to de-scribe or express the true chemical structure of certain compounds that cannot be accurately represented by any one valence-bond structure. It was originally applied to aromatic compounds as was originary applied to aromanic compounds such as beazene, for which there are many possi-ble approximate structures, none of which is completely salisfactory. See benzeme.

See bezzene.

The resonance concept indicates that the actual molecular structure lies somewhere between these various approximations, but is not capable of objective representation. This idea can be applied to any molecule, organic or inorganic, in which am electron pair bond is present. The term "resonance bytein" denotes a molecule that has the property. Such molecule control to the control of the property. Such molecule that has the property of t nor are they isotopes or mixtures; the resonance phenomenon is rather an idealized expression of

pnenomenon is rather an incention expression of an actual molecule that cannot be accurately pic-tured by any graphic device.

(2) In the terminology of spectroscopy, reso-nance is the condition in which the energy state of the incident radiation is identical with that of the incident radiation is identical with that of the absorbing stoms, molecules, or other chemi-cal entities. Resonance is applied in various

was soon followed by a petroleum-derived product called coumarone-indene, which did indeed have the properties of a resin. The first synthetic elastomer was polychloroprene (1931), origi-nated by Nieuwiand and later called neoprene. since then many new types of synthetic poly-mers have been synthesized, perhaps the most sophisticated of which are nylon and its conge-ners (polyamides, by Carothers) and the inor-mals allows of the constant of the conganle zillcone group (Kipping). Other important types are alkyds, acrylics, aminoplasts, polyvi-nyi halides, polyester, epoxies, and polyolefins. In addition to their many applications in plastics, textiles and paints, special types of synthetic

resins are useful as ion-exchange media. See "Curnar." See also plastic, paint, fiber, film.

Note: Because the term "resin" is so broadly used as to be almost meaningless, it would be desirable to restrict its application to natural organo-soluble, hydrocarbon-based products derived from trees and shrubs. But in view of the tronces are strong, but my vew of the tendency of inappropriate terminology to "gel" irreversibly, it is a losing battle to attempt to re-place "synthetic resin" with the more precise "synthetic polymer."

See also note under gum, natural.

resist. A material that will prevent the fixation of dye on a fiber, thus making color designs and pattern prints possible. The resist may act me-chanically, as a wax, resin, or get which prevents absorption of the dye, or its accompanying mor-dant. Ciric acid, oxalic acid, and various alkalies are among the more common resists of the chemical type.

realstor composition. A specially treated semi-conducting metal powder compounded with glass binders and temporary organic carriers. Can be applied to glass or ceramic surfaces by stenciling, spraying, brushing, or dipping; firing range 704-760C. Compositions can be bleuded with members of the same series to produce intermediate resistance values. Fired resistors have good reproducibility, low temperature and volt-age coefficients, and stability to abrasion, moisture, and relatively high (125C) ambient temperature

Use: To produce fired-on resistor components for electronic circuits.

"Resistox" [SCM]. TM for stabilized grades of Resistor." [SCAII]. TM for stabilized grades of copper powder assaying at greater than 99% copper with a density 8.9 and apparent density range of 2.0-3.5 g/cm<sup>2</sup>. Marketed in several grades of various particle sizes.

Use: Fabrication of porous bearings, statered fer-

rous machine parts, catalysts, magnesium chlo-ride cements, metal friction surfaces, electric brushes, electrical contacts, metallic paints.

RENNER OTTO

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RESIN, SYNTHETIC

Derivation: From Rauwolfia serpentina. Grade: USP. Hazard: Carcinogen in animals, potential caucer

risk in humans. Use: Antihypertensive agent, tranquilizer.

"Resigne" [Ozark-Mahaning]. TM for a series

of epoxy curing agents.

resident oil. A figuid or semiliouid product resulting from the distillation of petroleum and containing largely asphaltic hydrocarbons. Also known as asphaltum oil, liquid asphalt, black oil, petroleum tailings, and residuum. Combus-

unic.
Use: Roofing compounds, hot-melt adhesives, friction tape, sealants, heating oil for large buildings, factories, etc.
See also fuel oil.

See also fust our.

Note: Gasoline of 94 octans can be produced from residual oil in a high-temperature catalytic process, thus increasing the yield of garoline from a barrel of crude by 33% when full-scale production is achieved.

"Resimene" [Monanto]. TM for melamine and ureaformaldehyde resins. Supplied in organic liquid solutions. The melamine is also available in water-alcohol solution and soluble

spray-dry powders.

Use: Paint, varnish, lacquer for automobiles, machinery, appliances, construction; electronics, missiles; chemicals, pulp and paper.

resia. A semisolid or solid complex amorphous mix of organic compounds. Properties: It has no definite melting point and no tendency to crystallize. Derivation: Resine can be of animal, vegetable, or synthetic origin.

resissandus. C<sub>3</sub>,t<sub>10</sub>N<sub>2</sub>O<sub>4</sub>. Alkaloid from cer-tain species of Ramvolfia.

Properties: White or pale buff to cream-colored, odorless, crystallide powder; starkers slowly on exposure or light, more rapidly when in solu-tion; partially solubic in organic solvents; insol-llar: Medicine (antiboxers witho).

resinute. A salt of the resin acids found in rosin.
They are mixtures rather than pure compounds.
Use: See soap (2).

Use: Medicine (antihypertensive).

"Resto C" [Allied-Signal]. TM for a neutral synthetic coal-tar restin of high styrene content. Froperties: Light color, mp 115-123C, d 1.05, mineral oil cloud point 130-150C. Use: To impart alkali- and grease-resistance to floor tile.

resin, ion-exchange. See lon-exchange resin.

resin, liquid. An organic polymeric liquid that, resm. Hquat. An organic polymeric liquid that, when converted to its final state for use, becomes solid (ASTM), e.g., linseed oil, raw or heat-budled (partially polymerized).

See also drying oil; resinoid.

resin, natural. (1) Vegetable derived, amorphous mixture of carboxylic acids, essential oils, and terpenes occurring as exudations on the bark of many varieties of trees and shrubs. They are combustible, electrically nonconductive, hard and glassy with conchoidal fracture when cold, and soft and sticky below the glass transition point. Most are soluble in alcohols, ethers and carbon disulfide, and insoluble in water. The best known of these are rosin and balsam, ob-tained from coniferous trees; these have a high acid content. Of more remote origin are such acid content. Or more reduce origin are suita-resins as kauri, congo, dammar, mastic, san-drac, and copal. Their use in varnishes, adhe-sives and printing loks is still considerable, though diminishing in favor of synthetic products. (2) Miscellaneous types. Shellac, obtained from the secretion of an Indian insect, is still in general use as a transparent coating. Amber is a hard, polymerized resin that occurs as a fossil. nato, polymental team teams as a sossi-ester gum is a modified rosin. Amorphous suf-fur is considered an inorganic natural resin. Liq-uid redns, sometimes called resinoids, are repre-sented by linseed and similar drying oils.

See also gum, natural (note); resin, synthetic

resinoid. Any thermosetting synthetic resin, ci-ther in its initial temporarily fusible state or its final infusible state (ASTM). Heat-bodied lin-seed oil, partially condensed phenol-formalde-hyde and the like, are also considered resinoids.

resinol. A coal tar distillation fraction contain-ing phenols. It is the fraction soluble in benzeme but insoluble in light petroleum, obtained by solvent extraction of low temperature tars or similar materials. Resinols are very sensitive to beat and exidation.

réda, syalhetic. A man-made high polymer re-nulting from a chemical reaction between two (or more) subtances, susually with best or acti-tude of the control of the control of the total discount (dat/nonrel), but excludes modi-fied, water-actible polymers (often called re-rian). A distinction should be made between a synthetic resis and a plastic, he former is the polymer itself, whereas the latter is the polymer plass such additives as filters, colorana, plastici-plass such additives as filters, colorana, plastici-

ers, etc. . The first truly synthetic resin was developed by Backeland in 1911 (phenol-formaldehyde). This

uranlum-235 n from each the accepted he spent fuel on is effected d phosphate, pitation. The tium are sent :. The fission stored. Aness, has been Jum; here the um isotopes. cause its plud not be used sver, suitable adiation hazat require use mote-control radioactive ed. There are s operational il in Europe.

technique of i, and typosensitized pagay be coated oad potential communicad and surface and unusual

See octane

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cured state.

ances and gas storage vessels; adhesive for composites and for metals, glats, and ceramic; casting metal-forming toots and disc; encapsulation and the state of the state of the state of the state pressure vasteller fit. Eliament-wound pipe and pressure vasteller fit. Blament-wound pipe and pressure vasteller fit. The state of the state of the custron-thielding materials; rigid foams; call walls (to solidity andy formalisos); matrix for stained-plass windows; low-temperature mortars.

EPR. Abbreviation for ethylene propylene rubber, also for electron paramagnetic resonance.

epsilon acid. (1-naphthylamine-3,8-disulfonic acid). C<sub>10</sub>H<sub>2</sub>(NH)<sub>2</sub>(SO<sub>2</sub>H)<sub>2</sub>.

Properties: White, crystalline scales; soluble in

hol water, Derivation: Naphthalene-1,5- and 1,6-sulfonic acids are nitrated and reduced, giving 1-naphthylamine-3,8- and 4,8-disulfonic acids. Separaion is effected by crystallizing out the acid sodium saits of 1-naphthylamine-3,8-disulfonic acid.

Use: Azo-dye intermediate.

Epsom salts. See magneslum sulfate.

EPT. Abbreviation for ethylene-propylene terpolymer.

"Eptac No.1" [Du Pont]. TM for zinc dimethyldithlocarbamate, an ultra-accelerator for rubber.

"Estam" [Sauffer]. TM for a selective harbicide containing ethyl-N,N-di-n-propyithiolearbamate.

EPTC. (S-ethyldi-N.N-propylthiocarbamate). CAS: 759-94-4. C<sub>2</sub>H<sub>2</sub>SC(O)N(C<sub>3</sub>H<sub>2</sub>)<sub>2</sub>. Available forms: Liquid and granular formula-

Use: A pre-emergence herbicide.

eq. Abbraviation for gram equivalent weight, i.o., the equivalent weight in grams. Recommended as an international unit.

Equanii [Wyeth-Aperst]. Proprietary name for meprobamate. Use: Sedative.

equation of state. The mathematical formula which expresses the relationships between pressure, volume, and temperature of a substance in any state of aggregation.

equilibrium. (1) Chemical equilibrium is a condition in which a reaction and its opposite or reverse reaction occur at the same rate, resulting in a constant concentration of reactants; for example, animonia synthesis is at equilibrium when aminonia molecules form and decomposes at equal velocities (N<sub>2</sub> + 3H<sub>2</sub> -- 2NH<sub>3</sub>).

(2) Physical equilibrium is exhibited when two

(3) Physical equilibrium is exhibited when two or more phases of a system are changing at the same rate so that the net change in the system is zero. An example is the figuid-to-waper-waporto-liquid interchange in an enclosed system, which reaches equilibrium when the number of molecules leaving the liquid is equal to the number entering it.

resultivism constraint. A number that relates the concentrations of strating materials and products of a reversible chemical reaction to one another. For example, for a chemical praction represented by the equation  $a\lambda B + bCD - cAD + dCD$ , the suplification constants would be K = a and dCD the suplification constants when dCD are the sumbers of molecules of AB, CD, and CD that cover in the balanced equation and (AD), (BC), (AD), and (CD) are the molecules of CD, and CD is the sumbers of molecules of AB, CD, and CD in any mixture that is at equilibrium. At any one temperature, E is usually at least approximately the interpretation of CD is usually at least approximately the several mixtures, the sumbers of the spractical products when those of the starting materials are known. The constant changes markedly with temperature. The constant changes markedly with temperature. The constant changes markedly with temperature CD is the chemical formation in known, or by measuring all concentrations in known, or by measuring all concentrations.

equilibrium diagram: (constitutional diagram).

(1) A simplified boiling-point diagram, showing
for a liquid mixture the composition of the
vapor in equilibrium with the liquid. (2) A chart
showing the relation between a solution mut the
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equipartition, have f. Every particle, heavy or light, gaseous or liquid, and independent of its chemical nature or form, always possesses the same mean energy of translation at a given temperature.

equipotential energy. The energy existing at a constant potential throughout a system.

equivalent electrons. Electrons of equal azimuthal quantum numbers and principal quantum numbers. They have identical orbital properties but may have a difference in sign of their orbital moments. EPN

second crystal. This behavior is characteristic of 1,2-epaxybutune. See 1,2-butylene oxide. some types of high polymers.

EPN. (o-ethyl-o,p-nitrophenyl phenylphosphor-

ction (0-eusy-0,p-nuropneny) paesyspaosphor-othioate). CAS: 2104-64-5. C<sub>4</sub>H,P(C<sub>2</sub>H,O)(S)OC<sub>4</sub>H,NO<sub>2</sub>. Properties: Light yellow crystals, mp 36C, d 1.5978 (30C), insoluble in water, soluble in most organic solvents, decomposes in alkaline solu-

tions. Grade: Wettable powders and dusts. Hazard: A cholinesterase inhibitor, absorbed by skin, use may be restricted, TLV; 0.5 mg/m³ of

Use: Cotton insect pest control, acaricide.

"Epolene" [Tennessee Eastman]. TM for a series of low-molecular-weight polyethylene res-ins. Available in both emulsifiable and nonemulsifiable types.

Eponol" Resins. TM for high-molecular-weight linear copolymers of bisphenol A and epichlorohydrin; produce outstanding surface coatings by solvent evaporation alone.

"Epon" Resins [Shelf]. TM for a series of conagua: xeeus pareil. 1 m for a series of con-densation products of epichlorohydrin and bisphenol-A having excellent adhesion, strength, chemical resistance, and electrical properties when formulated into protective cont-ings, adhesives, and structural plastics.

"Epotuf" [Reichhold]. TM for epoxy resins, epoxy hardeners, and epoxy esters used as coating vehicles.

epoxidation. Reaction in which olefinic un-saturation is converted to a cyclic three-membered other by active oxygen agents.

epoxide. An organic compound containing a reactive group resulting from the union of an oxy-gen atom with two other atoms (usually carbon) at are joined in some other way as indicated:



This group, commonly called "epoxy," charac-terizes the epoxy resins. Epichlorohydria and ethylene oxide are well-known epoxides. The compounds are also being used in certain types of cellulose derivatives and fluorocarbons.

#### epoxidized linseed qli. See "Drapex" [ Witco].

"Epoxybond" [ Atlar]. TM for an epoxy adhesive putty in stick form.

# 3,4-epaxyxydohexane carbonitrile. $O(C_cH_\phi)CN$ .

Properties: Liquid, & 1.0929 (20/20C), bp 244.5C, fp -33C, soluble in water. Hazard: Toxic by skin absorption, ingestion, and inhalation. Use: Intermediate, stabilizer.

enoxyethane. See athylene oxide.

#### 2.3-epoxy-2-ethylhexapol.

#### C,H,CHOC(C,H,)CH,OH.

Properties: Liquid, d 0.9517 (20/20C), bp (decomposes), fp -65C, slightly soluble in water. Combustible.

Hazard: Skin irritant. Use; Stabilizer, intermediate.

epony novolak. Epoxy resin made by the reacpoory acovetak. Egoxy resin made by the reac-tion of epichlorobydrin with a novolak resin (phenol-formaldeh)de; see novolak). The have a repeating spoxide structure which offers better resistance to high temperatures than the epichlorohydrin-bisphenol A type, and are espe-cially useful as adhesives.

#### 2,3-epoxy-1-propanol. See glycidol.

epexy restn. A thermosetting resin based on the reactivity of the epoxide group. One type is made from epicholosylarian and bisphenol A. Aliphatic polyols such as glycerol may be used instead of the arronatic bisphenol A. Molecules of this type have glyddyl ether structures,

-OCH, CHOCH,, in the terminal positions, have many hydroxyl groups, and cure readily with

ammes.

Another type is made from polyolefins oxidized with peracetic acid. These have more epoxide groups, within the motecule as well as in terminal positions, and can be curred with anhydrides, but require with temperature. drides, but require high temperatures. Many modifications of both types are made commer-cially. Halogenated bisphenois can be used to add flame-retardant properties. See also epoxy novolak.

The reactive epoxies form a tight cross-linked

polymer network and are characterized by toughness, good adhesion, corrosive-chemical resistance, and good dielectric properties. reastance, and good dielectric properties.

Most epoxy rexins are the two-part type which harden when blended. A one-component liquid type for filament winding and a pelletized type for injection molding are available under the TM "Arnox."

Hazard: Strong skin writant in uncured state.

Use: Surface coatings, as on household appli-

Safety Data She	et 91/165/EEC (gb)		Manufacture of Friday					
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Revised: 12.09.2002	po Liai ao Gany, Gracoro		244,					
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Nipel 1000X 88	Nipol 1032	Nipol 1052-30 Nipol 35-5 SR						
Nipol 1000X 132	Nipol 1032-45	Nipol 1053	Nipol 35-8					
Nipol 1001CG	Nipol 1034-60	Nipol 1092-80	Nipol 40-5					
Nipol 1001LG	Nipol 1041	Nipol 1094-80	Nipol HR 662					
Nipol 1002	Nipol 1042	Nipol 30-5	Nipol HR 765					
Nipol 1014	Nipol 1042X 82	Nipol 33-3						
Nipol 1022	Nipol 1043	Nipol 33-5 HM						
Nipol 1022X 59	Nipol 1051	Nipol 33-8 HM						
Nipol 1031	Nipol 1052	Nipol 35-5						
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A			的的现在分词,一个一个时间的现在分词					
Substance		ECS CAS Range [	Symbol / R-phr.					
Acrylonitrile-Butadiene Polym		9003-18-3 ~100						
	and stitle number of the stitle by	None.						
No particular hazards known.		Methods for deaning up/taking up						
	Management 1 of 112 of 112 of 112	Take up mechanically. Dispose of absorbed material in accordance with the regulations.						
Seneral Information		Advice on safe handling						
ione.								
nhalation		Use only in wall-ventibled areas.						
iot applicable. Ikin contact		Advice on protection against fire and explosion						
ikin contact Consult a doctor if skin kribele		No special measures necessary.						
CONSULT & CELETON IT SIGN OFFICIALS	n persison.	Paralle						

Requirements for storage rooms and vessels Eye contact No special measures required. Not applicable. Advice on storage compatibility Ingestion Do not store together with oxidizing agents. Not applicable. Further information on storage conditions Advice to doctor Keep container in a well-vanifiated place. Store in a dry place. Protect from fight. Treat symptomatically 05 Fire fighting measures. diam's 1, 100. Exposure controls / personal protection Sultable extinguishing media Additional advice on system design

Water spray jet. Dry powder. Foam. Extinguishing media that must not be used Ingredients with occupational exposure limits to be monitored Full water let, Carbon dicade. Not applicable

Special exposure hazards arising from the substance or Respiratory protection Not applicable. preparation itself or combustion products Hard protection Protective gloves. Risk of formation of toxic pyrolysis products . Eye protection Not applicable. Special protective equipment for firefighters Skin protection Not applicable. Use self-contained breathing apparatus. General protective measures Additional information

Fire residues and contaminated firefighting water must be disposed of in accordance with the local regulations. Hygiene measures 2757 P. S. De Accidentalisation assumes the Property of the Pr Wash hands before breaks and after work, Use barrier skin cream. Personal precautions

Commission of the Commission o Ensure adequate ventillation . Environmental precautions Solid. 

Avoid contact with eyes.

Revised: 12.09.2002

Experiences made in practice

No todoological data are available.

Rehaviour in sewage plant

ysty curte Ecological Information

None.

General temarks

Blodegradable

Not applicable

Not applicable.

AOX-advice

No dangerous components.

General information

Product is insoluble in we

Contains compounds of 76464/EC

#### Safety Data Sheet 91/155/EEC (gb) NBR-Nipol-Standard-Standard Zeon Chemicals Europe Ltd. GB- Sully, CF64 5YU



The State of the S Colour: Yellow Odour: Characteristic. Dienocal / Product Not applicable. nH-value For recycling, consult manufacturer. Disposel in an incineration plant in accordance with the regulations of the local authorities. Boiling point [°C]: Waste no. 070299 Flash point [\*C]: Not sonliceble Disposal / Contaminated packaging Flammability: Uncontaminated packaging may be taken for recycling. Packaging that cannot be cleaned should be disposed of as for product. Lower explosion limit Upper explosion limit: Short I was great transport of committee we in the world Combustible properties: No The state of the s Vapour pressure [hPa]:(20°C) Density [g/ml]: not classified as Solubility in water: Dangarous Goo Dangerous Goods Declaration: Partition coefficient: n-octanol / Labelling Viscosity: Not applicable. Factor, ADR 1,1.3.6.3: Relative vapour density determined in air Hazard-no: Melting point ["C]: Autoignition temperature: ADR-Conditions for limited quantities(LQ): -Courses of Telephone and the country of the Country not classified as Dangerous Goods Dangerous Goods Declaration: Hazardous reactions Labelling If product is healed above decomposition temperature toxic vapours may be released. inner packing, max.: Hazardous decomposition products No hazardous decomposition products known. Total gross mass of a package: The state of the s Committees Characteristic according to Mode. 1.07 Takes Acute oral toxicity LD50 Rat: • IMDG-Code: not classified as Dangerous Goods LID50 Rebbit: -A cute dermal toylcity Dangerous Goods Declaration: Acute Inhalational toxicity LC50 Rat: -Irritant effect on eve Labelling Sensitization / Validation Label: Chronic toxicity / Validation Mutagenicity / validation IMDG-Conditions for limited quantities(LQ): Reproduction toxicity / Validation Dangerous Goods not classified as Dangerous Goods Carcinogenicity / Validation

Labelling

Inner packing, max.: —
Total gross mass of a —
package:

IATA-OGR: not classified as Dengerous Goods

Dangerous Goods Declaration: Labelling

Harried symbols

15 Fing mintony information.

Labelling
The product does not require a hazard warning label in accordance with
EC directives.

→ USPTO GENERAL 2011

Safety Data Sheet 91/155/EEC (gb) NBR-Nipol-Standard-Standard

Zeon Chemicals Europe Ltd. GB- Sully, CF64 5YU Revised: 12.09.2002



Special labelling for cartain preparations ( 77

Not applicable.

12/12 1 10/10 of September of September 12/12

Not applicable.

#### Regulatory Information

- 91/155 (2001/59) 67/548 (2001/59) 1999/45 (2001/50) 81/689 (2001/118) 89/542

- \* ADR (23.07.01) \* IMDG-Code (30.Amdt.) \* IATA-DGR (2002)
- \* Classification according to VeF \* Water hazard class
- Modified position:

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